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⑯ Read/write head slider with medium access aperture.

⑯ A read/write head slider for use with a disk drive, such as a floppy disk drive for a microcomputer, in which an aperture extends through the width of the head. The aperture allows access to the medium underneath the head which is being held relatively rigid by the head. Optical or electrical components can be positioned in or around the aperture, for example, to read optical servo tracking data from the medium.

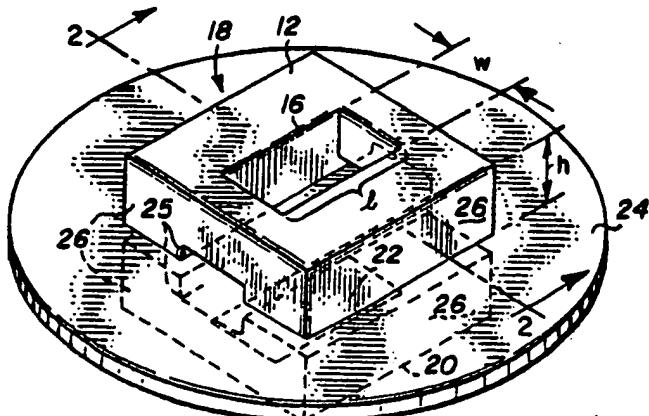


Fig. 1

## Read/Write Head Slider With Medium Access Aperture

### BACKGROUND OF THE INVENTION

#### Field of the Invention

The present invention relates to the read/write head slider of a disk drive system and more particularly to a read/write head having an aperture extending through the width of the head for accessing the underlying medium.

#### Description of the Prior Art

The track density of magnetic storage disks for conventional floppy disk drives is approximately forty-eight to one hundred thirty-five tracks per inch (TPI). In contrast, optical disk drives are capable of achieving track densities in excess of 15,000 TPI. These higher track densities are achieved through the use of closed loop optical servos that allow the read/write head to follow data track eccentricities caused by defects in the medium and by disturbances from outside forces. In rigid type magnetic disk drives, track densities of up to 1500 TPI are presently used. These drives commonly have multiple disks in which both sides are used for data. To achieve the high track density a dedicated surface of one of the disks is used for magnetic track servo information. This surface is then not usable for data storage. Thus, the total capacity of the drive is lessened. The tracking servo information is also capable of being accidentally erased causing loss of access of all data.

Various techniques have been reported for using optical means for acquiring track following servo information contained on a magnetic recording medium. For example, Ahn, et al in U.S. Patent 4,633,451, issued on December 30, 1986, for "Optical Servo For Magnetic Disks", disclose the use of a laser diode to read track following servo information in the form of a plurality of spots contained in an optical layer positioned above a magnetic recording layer.

DiStefano, et al, in U.S. Patent 4,570,191, issued on February 11, 1986, for "Optical Sensor for Servo Position Control", disclose a servo sensor comprising a light source and a light detector, axially aligned and contained on a single semiconductor chip.

M. Johnson, in U.S. Patent 4,558,383, issued on December 10, 1985, for "Information Storage Disk Transducer Position Control System Using a Prerecorded Servo Pattern Requiring No Alignment

With the "Storage Disk", discloses a servo apparatus having a sensor for detecting a pattern of spots on a surface of an information storage medium. The spots comprise a dense array of substantially translation invariant marks and separate information recording tracks are detected by measuring the rate at which the spots are detected by the sensor.

J. Cocke, et al, in U.S. Patent 4,587,579, issued on May 8, 1986, for "System for Position Detection on a Rotating Disk", disclose a servo control system comprising a detector for reading a plurality of spiral radial-position-encoding patterns on a medium.

A.S. Hoagland in "Optical Servo of Magnetic Recording", IBM Technical Disclosure Bulletin, Vol. 20(10), page 4108 (March 1978), suggests a system for achieving optical servo control where a flexible disk medium includes a plurality of optical servo tracks positioned underneath a magnetic layer.

D.A. Thompson, et al in "Embossed Servo Techniques For Floppy Disks", IERE Conference Proceedings, No. 43, p. 321 (July 1979), suggests the use of embossed marks on flexible magnetic media for obtaining non-magnetic optical or capacitive servo information.

N. Koshino and S. Ogawa in "Optical Method of the Head Positioning in Magnetic Disk Systems", preprint from IEEE Transactions on Magnetics (1980), disclose an optical head for achieving track following servo control which is mounting on the head arm and which includes an LED light source and three optical fibers for delivering light to a medium. The medium comprises a plurality of circular optical tracks, dyed black, and located underneath a magnetic film.

Related work has occurred in the laser video disk area, from which optical disks for digital data storage and the audio laser disk (CD) have evolved. Fundamentally, the optical servo information is inscribed and used in the same way for all these disks. A mastering machine is used to format optical information onto a master disk. The master is then replicated to form the actual disk used by the customer. A laser and associated optics are used to acquire the mastered servo information as well as read data from the disk. The data can be inscribed during the mastering process as with the video and audio disks or it can be written by the read/write laser as in disks for digital information storage.

None of the prior art cited above discloses a means for accessing the region of the medium that falls within the confines of the perimeter and thus covered by the read/write head.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a read/write head for a disk drive system in which the medium underneath the read/write head is accessible from outside the head.

It is another object of the present invention to provide a read/write head that allows access to a region of the medium that is relatively rigid.

It is another object of the present invention to provide a read/write head that minimizes the reading and writing error between the upper and lower heads.

It is another object of the present invention to provide a read/write head that maximizes the amount of medium surface area usable for information storage.

Briefly, a preferred embodiment includes a read/write head for a disk drive of an information storage system, such as a microcomputer, having an aperture extending through the width of the head. Typically, an upper head and a lower head are used together, with one head located on the upper and lower faces of a section of an information storage medium, such as a flexible magnetic disk. Either one or both of the heads can include the aperture.

The aperture provides access to the section of the medium lying underneath the head. The force exerted on the medium by the head holds the medium relatively rigid in the vicinity of the aperture. Additionally, when an upper and lower head are used, the error between the two heads in reading or writing is minimized because hysteresis or thermal expansion of the medium causes equal offsets to occur in the upper and lower heads.

A plurality of optical or electrical components can be positioned in or around the aperture. For example, a light source, such as a light emitting diode, and a light detector could be positioned in or around the aperture for reading optical servo information from the medium. This configuration maximizes the amount of usable medium surface area because extra medium is not required for writing surface information.

An advantage of the present invention is that the aperture in the read/write head provides access to the medium underneath the head.

Another advantage of the present invention is that the medium accessible underneath the head is held relatively rigid by the head.

Another advantage of the present invention is that the reading and writing error between the upper and lower heads is minimized.

Another advantage of the present invention is that the amount of usable medium surface area is

maximized.

These and other objects and advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiment which is illustrated in the various drawing figures.

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IN THE DRAWINGS

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Fig. 1 is a top elevational view of a read/write head slider having a medium access aperture in accordance with the present invention;

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Fig. 2 is a cross-sectional view of the read/write head slider taken along the line 2-2 of Fig. 1;

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Fig. 3 is a top elevational view of the read/write head slider with optical components positioned around the medium access aperture; and

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Fig. 4 is a top elevational view of the read/write head slider with the optical components positioned inside the medium access aperture.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

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Fig. 1 shows an upper read/write head slider 12 for an information storage device disk drive system containing a centrally located aperture 16. The information storage device could be, for example, the flexible disk drive of a microcomputer. The configuration of the read/write head 12 containing the aperture 16 is referred to as a hole-in-the-head configuration 18. A lower read/write head slider 20 which can include a lower head aperture 22 is positioned on the opposite side of a recording medium 24 from the upper head 12. In the preferred embodiment, the aperture 16 is centered around the approximate geometric center of the head 12 and extends completely through a width "h" of the head 12 thus providing a passageway between the upper and lower faces of the head 12 to the recording medium 24 at a location within the outer perimeter of the head 12. The shape of the aperture 16 is shown as being rectangular, but this shape is irrelevant and any other geometric shape, e.g. a circle or triangle or an irregular shape would suffice. The rectangular aperture 16 has a length "l" and a width "w". The width "h" of the head 12 is also the height of the aperture 16. Typically, "l" is approximately 0.140 inches, "w" is approximately 0.050 inches and "h" is approximately 0.060 inches.

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A plurality of notches 25 may be located on a plurality of faces 26 of the upper and lower heads 12 or 20 which do not include the apertures 16 or

22.

The lower read/write head 20 is substantially identical to the upper head 12 and may contain the lower head aperture 22. It should be noted that in some disk drive systems, the heads 12 and 20 are "read only" heads or "write only" heads. For purposes of the present invention, it is irrelevant if the read/write heads 12 and 20 perform both the read and write function (i.e. dual function head) or only one of these functions (i.e. single function head).

Hereafter, it should be understood that the word "head" refers to both single function and dual function heads. Additionally, it is not essential that the lower head 20 include the aperture 22.

In the preferred embodiment, the medium 24 is a magnetic medium such as a flexible or hard magnetic disk (i.e. floppy or Winchester disks). With a magnetic medium, the heads 12 and 20 must be magnetic read/write heads.

Fig. 2 shows a cross-sectional view of the heads 12 and 20 taken along the line 2-2 of Fig. 1. The apertures 16 and 22 provide a location for viewing the surface of the medium 24 that is otherwise covered by the heads 12 and 20 respectively. Various optical or electrical components can be positioned in or near the apertures 16 and 22. For example, Fig. 3 shows a light source 32, such as a light emitting diode or a laser, positioned to shine a beam of light 36 through the aperture 16. A detector 40 is positioned to receive a beam of light 44 reflected from the surface of the medium 24. In the situation where both the upper head 12 and the lower head 20 contain apertures, the light source 32 could be positioned in the aperture 16 and the detector could be positioned in the aperture 22.

Fig. 4 shows that the light source 32 and the detector 40 may also be positioned on the head 12 at a location inside the aperture 16 or at a location within the head 12 and with openings on the aperture 16. A cover 48 is used to restrict access to the aperture 16, for example, when the light source 32 is located inside the aperture 16. The cover 48 can be a separate piece from the head 12 which sits on the head 12 and covers the aperture 16 or which fits tightly inside the aperture 16. Alternatively, the cover 48 could be an integral part of the head 12 which essentially prevents the aperture 16 from extending completely through the width "h" of the head 12. In this case, the aperture 16 is said to extend substantially through the width of the head 12. Additionally, other optical components, such as fiber optic cables, or other electrical components, such as a capacitance measuring device, could be located in or around the aperture 16.

The light source 32 and the detector 40 may be used, for example, to read servo-tracking information on the surface of the medium 24. In this application, the hole-in-the-head configuration 18

provides several advantageous features. First, the surface of the medium 24 that is exposed by the aperture 16 is held relatively flat by the head 12. In the case of a floppy disk drive the medium 24 is held flat because while one head, e.g. head 12, is rigidly fixed, the other head, e.g. head 20, is allowed to comply to the fixed head. A load  $P_1$  is applied to head 20, thus pinching the medium 24 between the two heads. In a Winchester Drive, the medium is rigid and the heads are loaded and allowed to comply to the medium. Holding the medium 24 flat is important because it allows the distance between the medium 24 and the optic or capacitive devices located around the aperture 16 to be tightly controlled. If this distance were to vary, the optics, for example, would go out of focus. In contrast, the surface of the medium 24 outside the head 12 is free to vibrate or deform. This is particularly true with flexible magnetic media. Second, without the aperture 16, the surface of the medium 24 that is covered by the head 12 is neither visible nor accessible. Third, when the upper and lower heads 12 and 20 are utilized, the surface of the medium 24 exposed by the apertures 16 and 22 is at the geometric center point between the upper and lower heads 12 and 20. This means that if distortions occur in the medium 24, they are minimized by the configuration 18. For example, if thermal or hygroscopic expansion of the medium 24 occurs, the offset from the upper head 12 to servo tracking information on the surface of the medium 24 is equal to the corresponding offset between the lower head 20 and the servo tracking information. Fourth, the hole-in-the-head configuration 18 maximizes the amount of medium surface area usable for information writing. If the light source 32 and detector 40 are located outside the head 12, extra medium surface area would be required for writing servo information.

40 The apertures 16 and 22 may be prepared by several methods. For example, a precision drill may be used to drill a hole in an assembled head. Alternatively the pieces of an unassembled head could be designed so that the apertures 16 and 22 would be part of the assembled head configuration.

45 Although the present invention has been described in terms of the presently preferred embodiment, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

## Claims

1. A head for a disk drive system having an aperture extending substantially through a width of the head whereby access may be gained to an information carrying medium at a location within the perimeter of the head. 5

2. A head for a disk drive system comprising: a head for reading information contained on an information carrying medium with an aperture extending completely through a width of the head whereby access may be gained to the medium at a location within the perimeter of the head. 10

3. The head of claim 2 wherein, the head is capable of both reading and writing information on said medium. 15

4. The head of claim 2 wherein, said aperture has a rectangular shape. 15

5. The head of claim 2 wherein, said medium is a magnetic medium. 20

6. The head of claim 5 wherein, said magnetic medium comprises a flexible magnetic disk. 20

7. The head of claim 5 wherein, said magnetic medium comprises a rigid magnetic disk. 25

8. The head of claim 2 further comprising: a cover positioned on a surface area of the head containing at least part of said aperture whereby access to said aperture is restricted. 25

9. The head of claim 2 further comprising: a plurality of optical components located in close physical proximity to said aperture. 30

10. The head of claim 9 wherein, the plurality of optical components comprises a light source. 35

11. The head of claim 10 wherein, said light source comprises a light emitting diode. 35

12. The head of claim 2 further comprising: a plurality of electrical components located in close physical proximity to said aperture. 40

13. The head of claim 12 wherein, the plurality of electrical components comprises a means for measuring capacitance. 40

14. A method for reading servo-tracking information on a magnetic medium comprising the steps of: a. positioning a light source near an aperture in a head of a disk drive system; b. directing a ray of light from the light source through said aperture to a region of a magnetic medium within a perimeter of said head; and 50 c. detecting the ray of light with a detector after the ray of light encounters said magnetic medium. 55

15. The method of claim 14 further including the steps of: a. positioning said detector near said ap-

erture prior to detecting the ray of light; and  
b. directing the ray of light back to said aperture prior to detecting the ray of light.

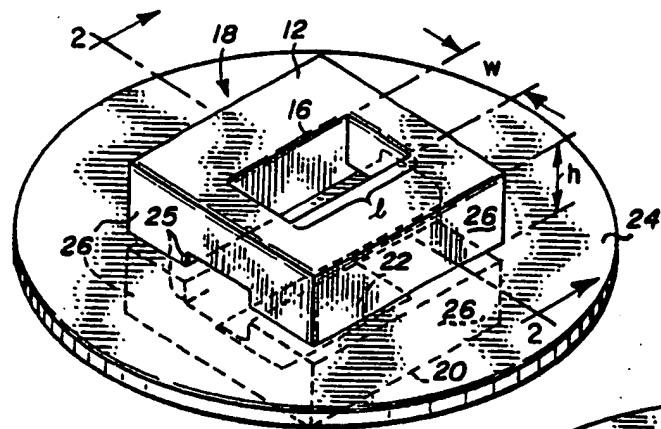


Fig. 1

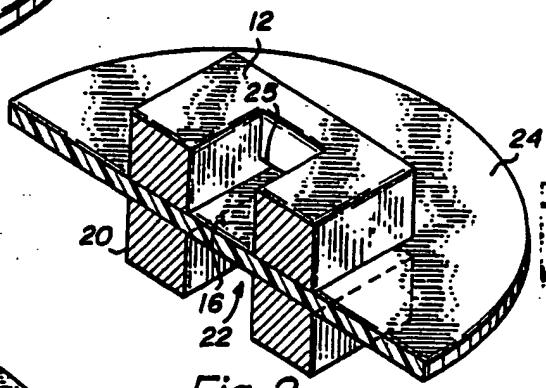


Fig. 2

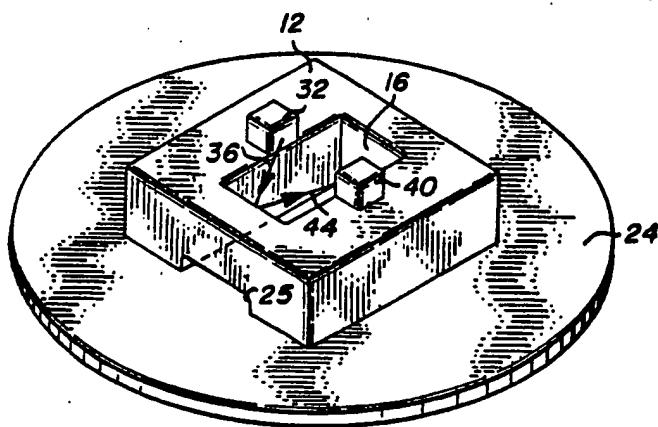


Fig. 3

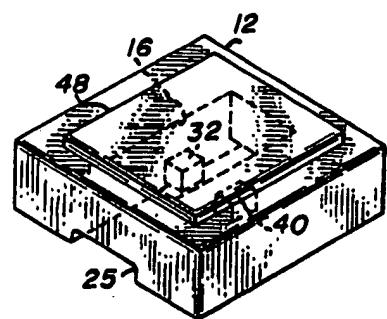


Fig. 4



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## EUROPEAN PATENT APPLICATION

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⑭ Date of filing: 20.07.89

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⑰ Date of publication of application:  
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㉒ Read/write head slider with medium access aperture.

㉓ A read/write head slider for use with a disk drive, such as a floppy disk drive for a microcomputer, in which an aperture extends through the width of the head. The aperture allows access to the medium underneath the head which is being held relatively

rigid by the head. Optical or electrical components can be positioned in or around the aperture, for example, to read optical servo tracking data from the medium.

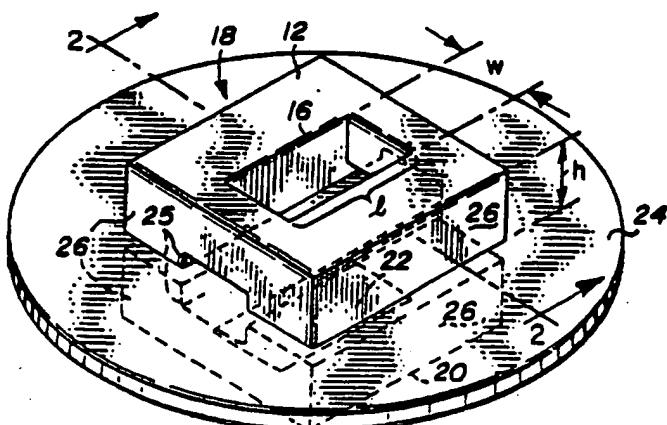


Fig. 1

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Patent Office

EUROPEAN SEARCH  
REPORT

Application Number

EP 89 11 3311

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	WO-A-8 502 933 (NCR CORPORATION) " page 1, line 1 - page 4, line 14 "	1-3,5-7, 9-12,14, 15	G 11 B 21/00 G 11 B 5/48 // G 11 B 5/58
X,A	PATENT ABSTRACTS OF JAPAN vol. 2, no. 20 (E-77)(11134) 9 February 1978, & JP-A-52 136612 (FUJITSU) 15 November 1977, " the whole document "	1-3,5,9, 10,12,1	
D,X	EP-A-0 168 699 (IBM) " page 1, lines 1 - 15 @ page 15, line 12 - page 17, line 13 @ page 19, line 4 - page 20, line 5 @ page 34, lines 3 - 8; figures 1-3, 7-10 "	1-3,5-12, 14,15	
Y,A	US-A-3 812 835 (ANDREWS ET AL) " column 1, line 1 - column 3, line 75; figures 1-4 "	1-7,9,10, 12,14,15, 8,13	
Y,A	US-A-4 029 944 (TRENKAMP) " column 3, line 25 - column 7, line 4; figures 1-7 "	1-7,9,10, 12,14,15, 11	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G 11 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	16 November 90	CALARASANU P.D.
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background Q: non-written disclosure P: intermediate document T: theory or principle underlying the invention</p> <p>E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons</p> <p>&amp;: member of the same patent family, corresponding document</p>		



EP 89 30 5590

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	IBM TECHNICAL DISCLOSURE BULLETIN. vol. 18, no. 1, June 1975, NEW YORK US pages 213 - 215; R. J. KELLER: "SENSING DEVICE FOR HOLES IN TRAVELLING TAPE" * the whole document *	1, 2	G11B23/087 G11B15/08 G11B23/34
Y	DE-A-3505985 (TELEFUNKEN) * page 6, lines 14 - 20; claims 1, 5; figures *	1, 2	
A	US-A-4492993 (D. A. OTIS) * column 3, line 25 - column 4, line 61; claims ; figures *	1, 2	
A	IBM TECHNICAL DISCLOSURE BULLETIN. vol. 14, no. 6, November 1971, NEW YORK US pages 1886 - 1887; R. A. BENDER: "POSITIVE POSITIONING OF CASSETTE TAPE UPON LOADING" * the whole document *	1, 2	
A	DE-A-2947215 (GIGGE REINHARD) * claims *	1, 2	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
D, A	US-A-3861619 (R. E. WOLFF) * column 2, line 29 - column 4, line 44; figures *	1, 2	G11B
The present search report has been drawn up for all claims			
1	Place of search THE HAGUE	Date of completion of the search 26 JUNE 1990	Examiner SCHWANDER
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			



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## EUROPEAN PATENT APPLICATION

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③ Date of publication of application:  
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② Designated Contracting States:  
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④ Magnetic tape cartridge identification.

⑤ A data cartridge includes a length of magnetic tape (15) which is formed at each end with a first pattern of holes (53,54,55,57,58,59) to enable identification of the end of the tape (15) and a second pattern of holes (74,76) located within the first pattern of holes (53,54,55,57,58,59) and configured to provide a binary code to enable automatic identification of the cartridge type or tape (15) type. The first pattern of holes (53,54,55,57,58,59) is different at each end of the tape (15) to further enable the automatic differentiation of one end of the tape (15) from the other end.

EP 0 347 074 A2

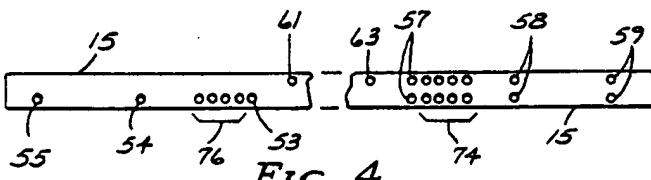


FIG. 4

Xerox Copy Centre

## MAGNETIC TAPE CARTRIDGE IDENTIFICATION

Field Of The Invention

The present invention relates to a magnetic tape cartridge in which the magnetic tape contained therein includes patterns of coding holes from which tape recorder functions may be automatically controlled.

Background Of The Invention

U.S. patent no. 3,861,619, assigned to the assignee of the present invention, recognized the desirability of automatic detection of the ends of the length of magnetic tape within reel-to-reel tape cartridges. That patent provided a length of magnetic tape which was formed adjacent each end with a repetitive pattern of holes, the patterns of holes at the two ends of the tape being different to distinguish the ends of the tape from each other. Two additional sets of holes, located more centrally of the length of tape, were also provided to demarcate the ends of the desired recording area of the length of recording tape.

This system worked well and was adequate when there existed only a limited variety of cartridge types and the length of tape and useful recording area was the only information necessary to successfully utilize the cartridges. Since that time, however, there has been a proliferation of cartridge types wherein the cartridges vary not only in tape length but also in such things as tape width and coercivity of the tape itself.

In order to utilize the present variety of cartridge types, the tape recorder must be able to sense numerous factors in addition to merely tape length.

Summary Of The Invention

According to the present invention, the tape recorder is provided with necessary information relating to the cartridge type or tape type by providing according to the present invention a magnetic tape cartridge which includes a cartridge shell defining an enclosure, a pair of reel hubs supported within the enclosure, and a length of magnetic tape extending along a tape path within the enclosure and having its ends wound one on each of the reel hubs, with the length of tape being formed at each end with a first pattern of holes to enable automatic identification of the end of the tape and a second pattern of holes located within the first pattern of holes and configured to provide

a code to enable automatic identification of such things as the cartridge type or tape type. Like the magnetic tape provided in U.S. patent no. 3,861,619 described above, the first pattern of holes is different at each end of the tape to enable the automatic differentiation of one of the ends of the tape from the other. The unique feature of the present invention is the second pattern of holes located within the first pattern of holes which provides a binary code in which "1"s and "0"s are indicated by the presence or absence of holes within the second pattern. This binary coding allows the magnetic tape to provide a virtually unlimited amount of identification data to the tape recorder and thereby allows the tape recorder to automatically adjust to the peculiarities of the tape cartridge and the magnetic tape contained therein.

The coding pattern located within the end-of-tape pattern may consist of a pattern which is unique from that of the end-of-tape pattern or it may be identical. In either case, the coding pattern is differentiated from the end-of-tape pattern by the spacing between the holes which define each pattern.

It is preferred in the present invention that all holes of all patterns be formed in the shape of an ellipse with its major axis aligned perpendicular to the length of the tape. This shape compensates for stretch of the tape by deforming to a desirable circular shape when the tape is in use.

Brief Description Of The Drawings

The present invention will be described with reference to the accompanying drawings, wherein like numbers refer to like parts in the several views, and wherein:

Figure 1 is a plan view of a magnetic tape cartridge constructed in accordance with the present invention, partially in section and in position on a recording and/or reproducing machine;

Figure 2 is a cross-sectional view taken generally along the line 2-2 of Figure 1;

Figure 3 is a perspective view illustrating a portion of the recording and/or reproducing machine shown in Figure 2;

Figure 4 is an elevational view of a first embodiment of a length of magnetic tape which may be contained within the cartridge of Figure 1;

Figure 5 is an elevational view of a second embodiment of a length of magnetic tape which may be contained within the cartridge of Figure 1; and

Figure 6 is an elevational view of a portion of the length of magnetic tape contained within the cartridge of Figure 1.

#### Description of the Preferred Embodiment

The magnetic tape cartridge of the present invention comprises a cartridge shell 10 defining an enclosure, a pair of reel hubs 12 and 13 supported within the enclosure for free rotation about spaced parallel axes and a length of magnetic tape 15 extending along a tape path within the enclosure and having its ends wound one on each of the reel hubs 12 and 13.

In Figures 1 and 2 the cartridge is shown in position in a recording and/or reproducing machine, hereinafter referred to as a tape recorder. The tape recorder comprises a support frame including a horizontal cartridge support deck 17 supporting a magnetic head 18 and, in a depending manner, supporting a reversible drive motor 20, the shaft of which extends through and carries a drive roller 21 above the support deck 17. Elongate guides 23 and 24 define the position for the cartridge on the cartridge support deck 17.

The cartridge shell 10 is formed with an opening 26 in its top wall and extending into one edge wall centrally of the length of the edge wall to provide access for the drive roller 21 of the tape recorder. The same edge wall of the cartridge shell is also formed with a cutaway portion 28 for access to the interior of the cartridge by the magnetic head 18. The cutaway portion 28 is normally covered by a door 29 which is pivoted on a stud 30 adjacent a corner of the cartridge and biased by a torsion spring toward its closed position covering the cutaway portion 28. The opposed edge walls 32 and 33 of the cartridge shell, which are perpendicular to the edge wall thereof containing the cutaway portion 28, are recessed along a majority of their length to expose the base wall, and the elongate guides 23 and 24 in the recorder are formed to fit over the exposed portion of the base wall of the cartridge shell to guide the cartridge as it is inserted into the recorder. The door 29 of the cartridge shell 10 extends beyond its pivot stud 30 into the recessed portion of the adjacent edge wall 32 and the leading edge of the corresponding cartridge guide 23 in the tape recorder is beveled to pivot the door 29 to an open position against the bias of the torsion spring as the cartridge is inserted into the machine.

The magnetic tape 15 is convolutely wound on the reel hubs 12 and 13 in opposite directions about their axes. The tape guide path between the reel hubs is defined by three guide pins 35, 36 and

37, one positioned at each side of the cutaway portion 28 of the cartridge shell 10 to guide the tape from the reel hub 12 and across the cutaway portion 28, and one pin positioned at the edge of the drive roller opening 26 farthest removed from the cutaway portion 28 to guide the tape to the reel hub 13.

A belt driving roller 39 is supported for free rotation by a shaft 40 extending from the base wall of the cartridge shell 10. The belt driving roller 39 is rotatable about an axis parallel to the axes of the reels 12 and 13 and it is positioned on the center line of the cartridge between the reel hubs. It is formed with a smaller diameter portion which has a central circumferential belt guide slot 41 in horizontal alignment with the center line of the tape guide path and a larger diameter portion 42 extending into the drive roller opening 26 in the cartridge shell 10. The larger diameter portion 42 of the belt driving roller 39 extends over the tape path between the guide pins 36 and 37 to permit driving of the belt driving roller 39 by the drive roller 21 in the tape recorder without contacting the tape 15.

A pair of belt guide rollers 44 and 45 are supported on the cartridge shell by stationary shafts 47 and 48, respectively, for rotation about axes parallel to the axis of the belt driving roller 39. The belt guide rollers 44 and 45 and their support shafts 47 and 48 are constructed of materials which have a predetermined coefficient of friction to provide a predetermined frictional coupling between each guide roller and its support shaft. The belt guide rollers are positioned at opposite corners of the cartridge shell 10 along the edge wall thereof parallel to the edge wall formed with the cutaway portion 28. Each belt guide roller is formed with a central circumferential belt guide slot in horizontal alignment with the guide slot 41 in the belt driving roller 39. The belt driving roller 39 and the belt guide rollers 44 and 45 define a belt guide path having an angle of wrap of at least 60° at the periphery of the reel hubs 12 and 13.

A thin, continuous, flexible and elastic belt 50 having a uniform cross-sectional area extends along the belt guide path around the belt driving roller 39 and the belt guide rollers 44 and 45 and contacts the tape 15 on the reel hubs 12 and 13. The belt 50 has a coefficient of elasticity in the range from 0.01 to 0.25 meters per newton meter. The length of the belt 50 is less than the length of the belt guide path so that when the belt is stretched into position along the guide path it will have an installed tension or pretension of at least 1.6 newtons.

Rotation of the belt driving roller 39 in the clockwise direction (as viewed in Figure 1) by the drive roller 21 causes the belt 50 to traverse its guide path in a clockwise direction and the tape 15

to move from the reel hub 12 to the reel hub 13, the reel hub 12 serving as a supply reel and the reel hub 13 serving as a take-up reel. The predetermined frictional coupling between the belt guide rollers 44 and 45 and their respective support shafts 47 and 48 applies a predetermined drag to the belt as it passes around the guide rollers, thereby increasing the tension in the belt as it passes around each of the guide rollers. This increased tension in the belt 50 increases the length of the belt, according to the elasticity of the belt, thereby increasing the speed at which the belt passes around the take-up reel 13 over that at which it passes over the supply reel 12. This increased speed causes tension in the tape 15 as well as the ability to take up any slack developed in the tape between the reel hubs. Reversal of the direction of rotation of the belt driving roller 39 (i.e., counterclockwise as viewed in Figure 1) will result in transfer of tape from reel hub 13 to reel hub 12 with the same tape drive properties.

As described in U.S. patent no. 3,861,619, the length of magnetic tape 15 is formed adjacent each of its ends with a first repetitive pattern of holes 53, 54, 55 and 57, 58, 59, respectively. The pattern of holes adjacent one end comprises a single hole 53, 54 or 55, the pattern being repeated three times. The pattern of holes adjacent the other end of the tape comprises two holes 57, 58 or 59 aligned across the width of the tape, the pattern being repeated three times. Each unit within the first pattern of holes may be termed a "cell" of information. For example, the set of two holes 57 within the first pattern 57, 58, 59 comprises a cell within the first pattern of holes. The differences in the cells, i.e., single holes and double holes, distinguishes the ends of tape from each other.

The length of magnetic tape 15 is also formed with two additional sets of holes 61 and 63 more centrally of the length of tape and distinguishable from the repetitive patterns 53, 54, 55 and 57, 58, 59. One additional set of holes 61 or 63 is associated with each end of the length of tape, the additional sets of holes together demarking the approximate ends of the desired recording area on the length of magnetic tape 15. In the illustrated embodiment each additional set of holes comprises a single hole 61 or 63, the two holes 61 or 63 being on the same level across the width of the magnetic tape 15 between two predetermined longitudinal recording tracks on the tape. The additional sets of holes 61 and 63 are distinguishable from the single holes 53, 54, 55 at one end of the tape by being on a different level across the width of the magnetic tape 15 and they are distinguishable from the patterns of holes 57, 58, 59 at the other end of the tape by being single holes rather than pairs. The additional holes 61 and 63 are also

smaller than the holes of the repetitive patterns 53, 54, 55 and 57, 58, 59 to eliminate any possibility of their interfering with the adjacent recording tracks.

A mirror 65 is supported by the cartridge shell

- 5 10 at a 45° angle to the tape path along the front edge wall of the cartridge to reflect light from a lamp 67 in the tape recorder against the rear face of the magnetic tape 15. A pair of vertically aligned photocells 69 and 70 are positioned adjacent the cartridge position to collect light reflected by the mirror 65 and transmitted through the holes in the magnetic tape 15. The upper photocell 69 is horizontally aligned with the upper course of holes through the magnetic tape 15 and the lower photocell 70 is aligned with the lower course of holes. The photocells 69 and 70 are electrically connected to a logic circuit which is illustrated schematically in Figure 2 by the box 72.

The logic circuit 72 provides control of the

- 20 drive motor 20 and recording by the magnetic head 18. When the cartridge is inserted into the tape recorder and the tape recorder is activated, the logic circuit 72 activates the drive motor 20 to search for an end of the magnetic tape 15. For example, suppose that the hole 61 is initially adjacent the mirror 65 and the drive motor is activated to transport the magnetic tape 15 from reel 12 to reel 13. In this case the transport would continue until the hole 53 passed between the mirror 65 and the photocell 70, indicating that the left end of the tape (as viewed in Figure 4) had been found. The logic circuit would then cause the power to be removed from the drive motor 20. Now if the cartridge is removed from the machine and reinserted, the drive motor 20 may be activated in the same direction and this time sensing of hole 54 by the photocell 70 would tell the logic circuit that the left end of the length of magnetic tape 15 was present and the power to the drive motor 20 would again be removed.

Activation of the tape recorder in the recording mode will now cause the logic circuit 72 to control the drive motor 20 to drive in the opposite direction transferring tape from reel 13 to reel 12. Tape is

- 45 transported without recording until the hole 61 passes between the mirror 65 and the photocell 69 at which time the logic circuit 72 is told that the beginning of the recording area has been reached. The logic circuit 72 then enables the magnetic head 18 to permit recording on the length of magnetic tape 15. Recording may then be continued until the hole 63 passes between the mirror 65 and the photocell 69, at which time the logic circuit 72 is told that the end of the tape is approaching and recording must soon be discontinued. When the first pattern of holes 57 at the end of the tape passes between the mirror 65 and the photocells 69 and 70 the photocells indicate to the logic

circuit that the right end of the tape has been reached and the power is removed from the drive motor 20.

Now, again, if the cartridge is removed from the tape recorder and reinserted the patterns of holes 58 and 59 at the right end of the length of magnetic tape protect the tape from being pulled from the reel hub 13 if the drive motor 20 is activated in the same direction. With the cartridge in this condition, the magnetic tape being substantially transferred to the reel 12, the right end of the tape may serve as the beginning for a second recording track on the length of magnetic tape 15. For this reason the holes 61 and 63 are formed on the same level across the width of the tape and are spaced the same distance from the adjacent patterns of holes 53 and 57, respectively. Thus, when the tape is being transferred from reel 13 to reel 12 hole 61 serves as the load point to determine the beginning of recording and hole 63 serves as the early warning point to signal that recording should soon be ended, while when the tape is moved from reel 12 to reel 13 hole 63 serves as the load point and hole 61 serves as the early warning point.

According to the present invention, and as illustrated in Figure 4, the length of tape 15 is modified by the addition of a second pattern of holes 74 within the first pattern of holes 57, 58, 59 at one end, and a second pattern of holes 76 within the first pattern of holes 53, 54, 55 at the other end. The second pattern of holes 74 and 76 consist of a succession of cells equally spaced along the tape 15 to provide a binary code in which "1"s and "0"s are indicated by the presence or absence of a hole or holes in the second pattern 74 or 76. As previously defined, a cell is one or more associated holes positioned along the length of the tape 15. The binary data imparted by the second pattern of holes 74, 76 may be utilized by the logic circuit 72 to automatically identify such things as the cartridge type or tape type.

The second pattern of holes 74, 76 is differentiated from the first pattern of holes 57, 58, 59 and 53, 54, 55 by the spacing of the cells, wherein the spacing of the cells comprising the second pattern of holes is significantly shorter than the spacing between the cells of the first patterns of holes 57, 58, 59 and 53, 54, 55. The spacing between cells need not be equal as shown in Figures 4 and 5, but it must be shorter than the spacing of the first pattern of holes. It is noted that although four cells are indicated in Figure 4 as comprising the second pattern of holes 74 or 76, there is no particular significance attached to this number. The number of cells may be fewer or greater, depending upon the amount of information it is necessary to impart to the logic circuit 72. It is also to be noted that either the presence or absence of holes at a cell

location within the second pattern of holes can be interpreted by the logic circuit 72 as a "1" or a "0" to impart binary information to the logic circuit 72.

Operation of the drive as controlled by the logic circuit 72 is also modified according to the present invention as follows. When the tape is wound so as to cause the photocells 69 and/or 70 to encounter one of the cells of the first pattern of holes 57, 58, 59 or 53, 54, 55, the drive direction of the tape 15 is reversed until one of the additional sets of holes 61 or 63 is encountered. The drive direction of the tape 15 is then once again reversed toward the associated second set of holes 74 or 76. Passage of the second set of holes 74 or 76 before the photocells 69 and/or 70 imparts binary data to the logic circuit 72 to provide the information necessary for the automatic identification of such things as cartridge type or tape type. As noted above, the second pattern of hole 74 or 76 is identified by the logic circuit 72 by the different spacing of the second pattern of holes 74 or 76 from the first pattern of holes 57, 58, 59 or 53, 54, 55, respectively.

As shown in Figure 4, it is preferred that the individual cells of the second pattern of holes 74 or 76 be identical to the associated first pattern of holes 57, 58, 59 or 53, 54, 55 within which the second pattern of holes 74 or 76 is located. The reason for this identity between the individual cells of the first pattern of holes 57, 58, 59 and 53, 54, 55 and the second pattern of holes 74 and 76 is so that the second pattern of holes 74 and 76 may perform the dual function of providing the binary data necessary for identification and providing the end-of-tape function normally attributed to the first pattern of holes 57, 58, 59 and 53, 54, 55.

For example, if the tape 15 were positioned with respect to the photocells 69 and 70 such that the photocells 69 and 70 were located between the first cell 57 of the first pattern of holes 57, 58, 59 and the first cell of the second pattern of holes 74, and wound toward the holes 59 of the first pattern of holes 57, 58, 59, the logic circuit 72 would first encounter the first cell of the second pattern of holes 74. Since the first cell of the second pattern of holes 74 is identical to the cells of the first pattern of holes 57, 58, 59, the first cell of the second pattern of holes 74 would be interpreted as one of the cells of the first pattern of holes 57, 58, 59 and the tape drive direction reversed until the additional hole 63 was encountered. Then, as described above, the tape 15 would be wound toward and through the second pattern of holes 74 to provide the necessary binary identification information. In this instance, therefore, the first cell of the second pattern of holes 74 functions as both an end-of-tape marker and also the first binary item of information imparted to the logic circuit 72. To

allow the second pattern of holes 74 to provide this dual function, it is preferred that the individual cells of the second pattern of holes 74 match the individual cells of the first pattern of holes 57, 58, 59. The preferred identity of cells between the first pattern of holes 57, 58, 59 and the second pattern of holes 74 is desirable because it speeds initiation of the necessary reversal and reversal again of the tape 15 to read the information contained in the second pattern of holes 74.

It is possible, however, that the second pattern of holes 74 or 76 need not contain cells which match the cells comprising the first pattern of holes 57, 58 and 59. In this case, if the tape 15 were positioned as described above, the tape would simply travel through the second pattern of holes 74 until the cell 58 of the first pattern of holes 57, 58, 59 was reached.

Figure 5 illustrates that the individual cells of the various patterns of holes may vary considerably and still achieve the desired end. The tape 15 of Figure 5 is provided with a first pattern of holes 78, 80 and 82 at one end wherein each individual cell is simply a single hole. The second pattern of holes 84 associated with this end of the tape 15 likewise has individual cells which merely consists of a single hole. The remaining end of the tape 15, however includes cells which consist of two closely spaced holes separated by a relatively greater distance. In any of the patterns illustrated in Figures 4 or 5, it is noted that the first pattern of holes associated with one end of the tape 15 is different from the first pattern of holes associated with the remaining end of the tape 15 so that the ends of the tape may be differentiated from each other. It also should be noted that the individual cells of the second pattern of holes in any example preferably are identical to the individual cells of the associated first pattern of holes for the reasons discussed above.

Figure 6 illustrates a modification to the foregoing pattern holes which results in improved reliability of reading each individual hole. It has been observed that the punching of holes in the tape 15 results in localized stress concentrations and consequential distortion of the tape 15 which causes the circular shape of the hole to become distorted. As shown in Figure 6, this distortion of the holes is compensated for by punching the holes in the shape of an ellipse 86 (shown in solid lines) which has its major axis aligned perpendicular to the length of the tape 15. Upon stretching of the tape 15 during use, the elliptical shape 86 is distorted to a circular shape 88 (shown in phantom lines) which is most desirable from a standpoint of reliable reading by the photocells 69 and/or 70.

## Claims

1. A magnetic tape cartridge comprising:  
a cartridge shell (10) defining an enclosure;

5 a pair of reel hubs (12,13) supported within said enclosure;  
a length of magnetic tape (15) extending along a tape path within said enclosure and having its ends wound one on each of said reel hubs (12,13);  
10 said length of tape (15) being formed at each end with a first pattern of holes (53,54,55,57,58,59) to enable automatic identification of said end of said tape (15) and defined by a succession of cells each consisting of one hole (53,54,55) at one end of said tape (15) and a succession of cells each consisting of two or more closely associated holes (57,58,59) arranged across the width of said tape (15) on a line perpendicular to the length of said tape (15) at the other end of said tape (15); and  
15 20 a second pattern of holes (74,76) located between two of said successive cells of said first pattern of holes (53,54,55,57,58,59) and configured to provide a code to enable automatic identification of the cartridge type or tape (15) type.

25 2. A cartridge according to claim 1 wherein said second pattern of holes (76,76) consists of successive cells of holes configured identically to said cells of said first pattern of holes (53,54,55,57,58,59) within which said second pattern of holes (74,76) is located.

30 3. A cartridge according to claim 1 wherein said holes of said first (53,54,55,57,58,59) and said second patterns (74,76) are ellipses (86) with the major axis of each hole oriented perpendicular to  
35 the length of said tape (15).

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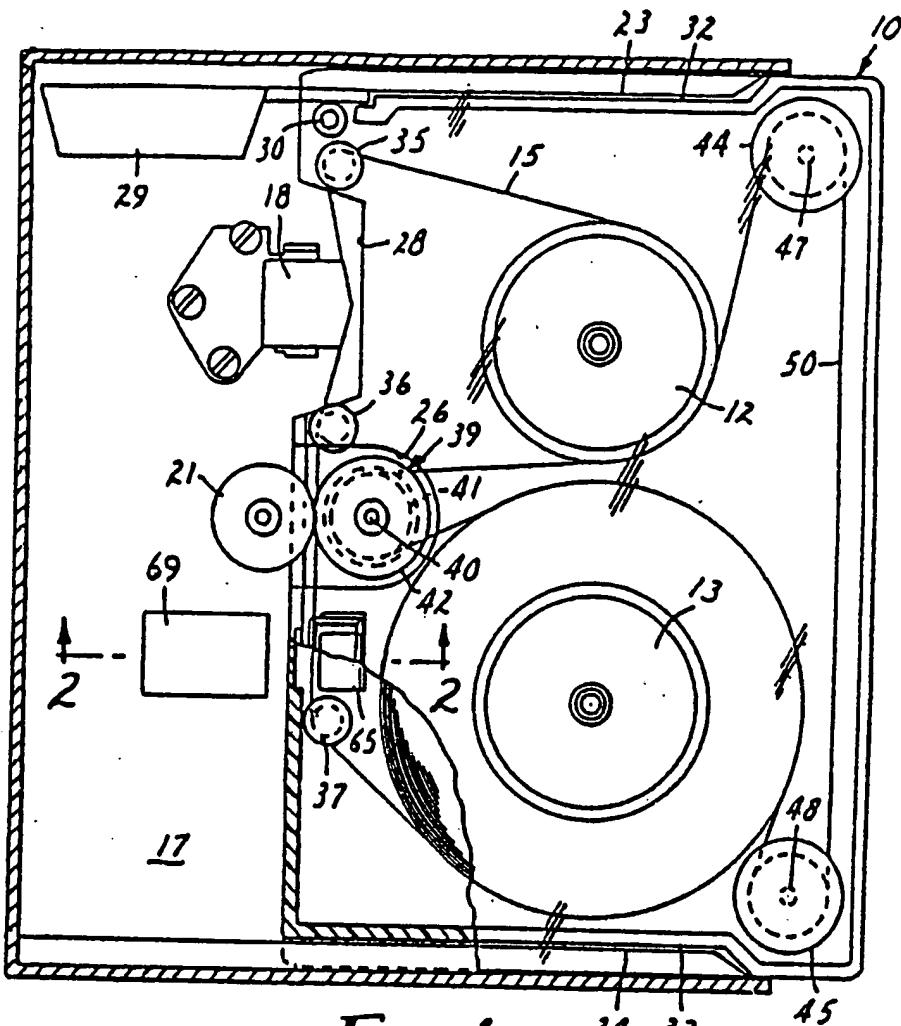


FIG. 1

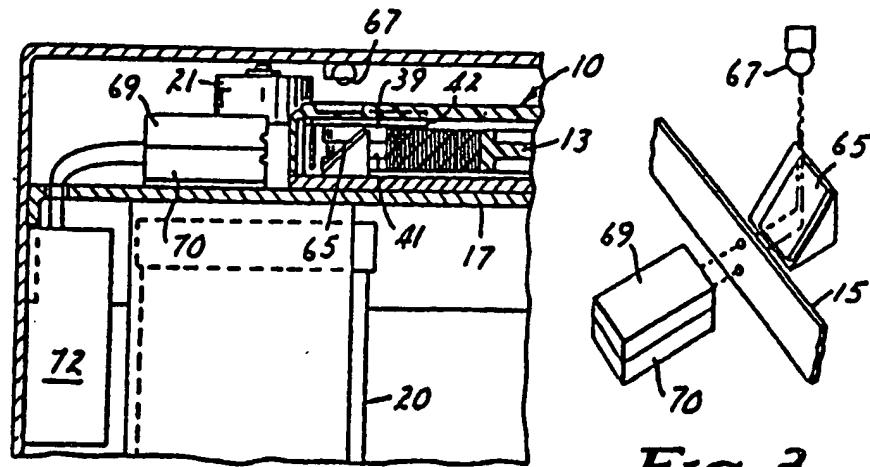
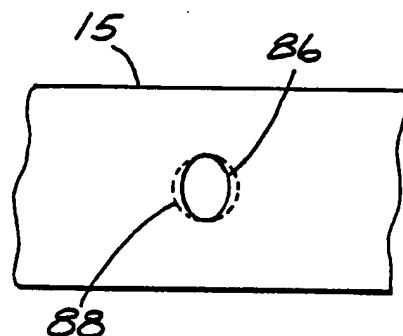
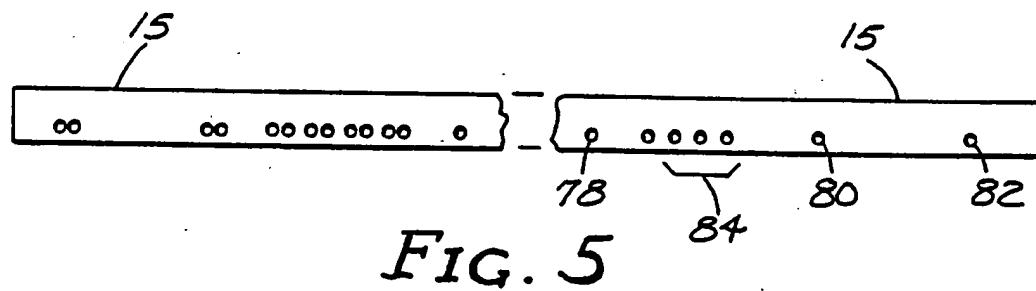
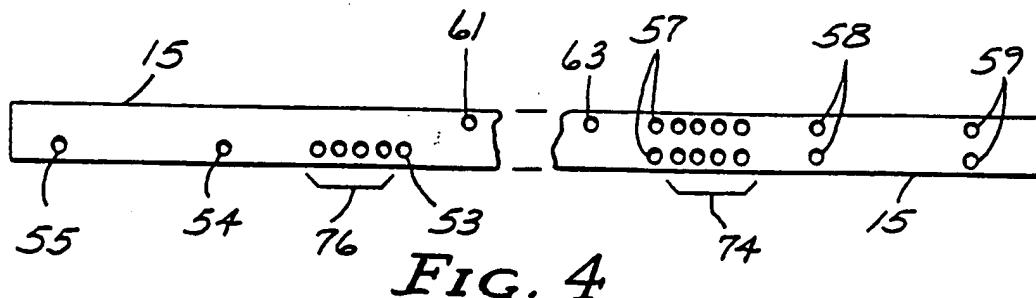


FIG. 2

FIG. 3





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⑮ Magnetic tape cartridge identification.

⑮ A data cartridge includes a length of magnetic tape (15) which is formed at each end with a first pattern of holes (53,54,55,57,58,59) to enable identification of the end of the tape (15) and a second pattern of holes (74,76) located within the first pattern of holes (53,54,55,57,58,59) and configured to

provide a binary code to enable automatic identification of the cartridge type or tape (15) type. The first pattern of holes (53,54,55,57,58,59) is different at each end of the tape (15) to further enable the automatic differentiation of one end of the tape (15) from the other end.

